

Chapter 11 Summary

TEACHING AND LEARNING WITH TECHNOLOGY IN MATHEMATICS AND SCIENCE INSTRUCTION

David Cogswell

1 . Issues and Problems in Mathematics Instruction—Each current issue has implications for how teachers can and should integrate technologies, including:

- accountability for standards in mathematics,
 - Six principles address crucial issues fundamental to all school mathematics programs:
 1. Equity
 2. Curriculum
 3. Teaching
 4. Learning
 5. Assessment
 6. Technology
 - NCTM Standards
 - Five content standards include:
 1. Numbers and Operations
 2. Algebra, Geometry
 3. Measurement
 4. Data Analysis
 5. Probability
 - Five process standards include:
 1. Problem Solving
 2. Reasoning and Proof
 3. Communication
 4. Connections
 5. Representations
- challenges in implementing the principles and standards for school mathematics,
 - Research points to three implications for the selection and use of technology related to mathematics education.
 1. Teachers should consider an appropriate combination of off- and on-computer activities.
 2. They should consider technology as a mathematical tool rather than as a pedagogical tool.
 3. They should view technology as a tool for developing student thinking.
 - One way to accomplish these goals is to use computer software and applications that can be extended for long periods of time across topics to engage students in meaningful problems and projects rather than providing a variety of applications with no internal coherence.
- directed vs. constructivist teaching strategies: ongoing “math wars.”
 - “those who believe math should be explicit and teacher-directed or those who favor student-centered learning—a more constructivist approach in which

students forge conceptual understanding through group work, hands-on projects, or discussions with other students”

2. Technology Integration Strategies for Mathematics Instruction—Integration strategies offer support for:

- Bridging the gap between abstract and concrete with virtual manipulatives,
 - research has found that virtual manipulatives have positive impact on both attitudes toward mathematics and student achievement.
 - virtual manipulatives can improve high school students’ attitudes toward mathematics.
 - virtual manipulatives may actually be better than physical ones for young children who are learning to connect concrete and abstract number concepts.

- allowing representation of mathematical principles,
 - Technology has greatly enriched the way the abstractions of mathematics can be represented, and today students must learn mathematics using several representations: symbolic (with numerals, variables, equations, and so on), verbal (with words such as “What percent increase is needed to reach \$32,000?”), graphical (using two- or three-dimensional graphs), or numerical (using tables of numbers or spreadsheets). For each of these representations, technology resources have been developed to allow learners to explore mathematics within that representation—and to explore the interaction among representations.
- supporting mathematical problem solving,
 - NCTM defines problem solving as “engaging in a task for which the solution method is not known in advance.” In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings.
 - the true value of mathematics is realized only when they can apply their knowledge to solve problems.
 - Technology, by its definition, is a tool for solving problems.
 - implementing data-driven curricula,
- supporting math-related communications,
 - Expressing numerical ideas in textual form is essential; therefore, students must be able to convert their mathematical thinking into words.
 - Student-created websites
 - Using computers and calculators in small-group settings also promotes social interaction and discourse.
- motivating skill building and practice.
 - Provides motivating practice in foundation skills required for higher-level learning
 - Provides guided instruction in a structured learning environment

3. Issues and Problems in Science Instruction—Each of these current issues has implications for how teachers can and should integrate technologies, including

- accountability for standards in science,
 - Technology can play an important and integral role in inquiry-oriented science instruction.
- the narrowing pipeline of scientific talent,
 - America faces a growing crisis in leadership for much-needed science/technology/engineering/mathematics (STEM) initiatives. This trend could have serious consequences for the long-term economic and national security of our country.
- increasing need for scientific literacy,
 - America’s economic and environmental progress depends on the character and quality of the science education that the nation’s schools provide.
- difficulties in teaching K–8 science,
 - Science is a rapidly changing area, and teachers are constantly challenged to keep up with new developments in science content, tools, and methods.
 - teaching science for understanding at an early level becomes difficult due to teachers’ lack of deep understanding of the discipline.
- objections to virtual science labs.
 - Virtual schools, among others, have proposed that simulated labs for activities such as experiments with chemical compounds and animal dissections in biology are very much in keeping with the idea of hands-on learning. They maintain that students can spend more time focusing on the “science” of the activities when danger and sensory unpleasantness are removed.
 - American Chemical Society (2008) take issue with this view, saying that “hands-on” means that students must touch the materials rather than “do” science on a computer.

4. Technology Integration Strategies for Science Instruction—Integration strategies offer support for: Involving students in scientific inquiry through

- authentic online projects,
 - Involving students in active scientific investigations can improve their attitude toward science as well as their understanding of scientific concepts.

- These projects give them experience with all aspects of the scientific approach: asking new and novel questions, setting up researchable hypotheses, collecting and analyzing data, communicating the results, and getting feedback to help interpret and refine results.
- GLOBE is an environmental science project that has students investigate the weather, land cover, soil, and hydrology, and record their observations at the GLOBE site.
- Project FeederWatch from Cornell University, which provides teachers with a bird identification key and instructions for stocking a bird feeder, gathering data, and submitting the information to the site.
- Journey North engages students in a global study of wildlife migration and seasonal change.
- support for specific processes in scientific inquiry,
 - The Internet has become an indispensable tool for investigating important scientific questions.
 - Data collection and archiving are important parts of the scientific inquiry process.
 - A number of visualization tools exist that allow students to see representations of data and phenomena that may be difficult to observe directly.
- Analyzing data can be done with a number of existing programs that come standard on computers.
- Once data are analyzed, scientists write up the results and submit them for publication using standard productivity software (e.g., word processing).
- supporting science skills and concept learning,
 - Though hands-on science remains the major science instructional strategy, online science lessons and games can provide motivational ways to supplement this instruction.
- engaging students in engineering topics through robotics,
 - Robotics camps and competitions had great effect on improved attitudes toward science and technology and made kids excited about learning more.
- accessing science information and tools.
 - The Internet has opened up a world of tools and materials for use by teachers and students.
 - remote online telescope
 - unlimited source of data for classroom experiments and investigations
 - a wide variety of current, useful publications in science and science education.
 - exchange ideas and teaching strategies

5. Tech-PACK Needs and Challenges in Mathematics and Science Instruction—To integrate technologies effectively, teachers must have a combination of science and mathematics:

- content knowledge,
 - the set of concepts and skills students will be required to learn has grown and changed over time and will continue to do so.
 - an increasing number of jobs that never required mathematical or scientific skills are now dependent on them.
 - To help train the workforce of tomorrow, all mathematics and science teachers must keep updated on what these new requirements mean for their own content knowledge.
 - Teachers at the younger levels must become content experts in mathematical and science topics they may not have learned in their basic teacher education programs.
- pedagogical knowledge,
 - They must teach in ways that are engaging and motivational, yet highly effective in raising achievement.
 - Learning by doing requires a constructivist mindset that is new to many teachers
- technological knowledge.
 - In order to teach students to use the technology tools of mathematics and science, teachers must become masters of these tools.
 - They must also be well-acquainted with the growing number of online tools that can help support hands-on lessons.
 - They must know how to employ distance education tools that can help them keep in touch with their students and updated on their content and pedagogy.

Strategies for improving your Tech-PACK in these areas are given.

- Do I have the mathematics and/or science content knowledge I need to assist my students in meeting the standards within my classroom?
- Do I have the technological knowledge needed to teach the mathematics and/or science content within my classroom?
- Do I have the pedagogical knowledge needed to teach the mathematics and/or science content within my classroom?

